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February 3, 2009

Senator Jerry Black
445 O'Haire Blvd
Shelby, MT 59474-1950

RE: The Case for Compressed Air Energy Storage
Sent via email to: blacks@3rivers.net

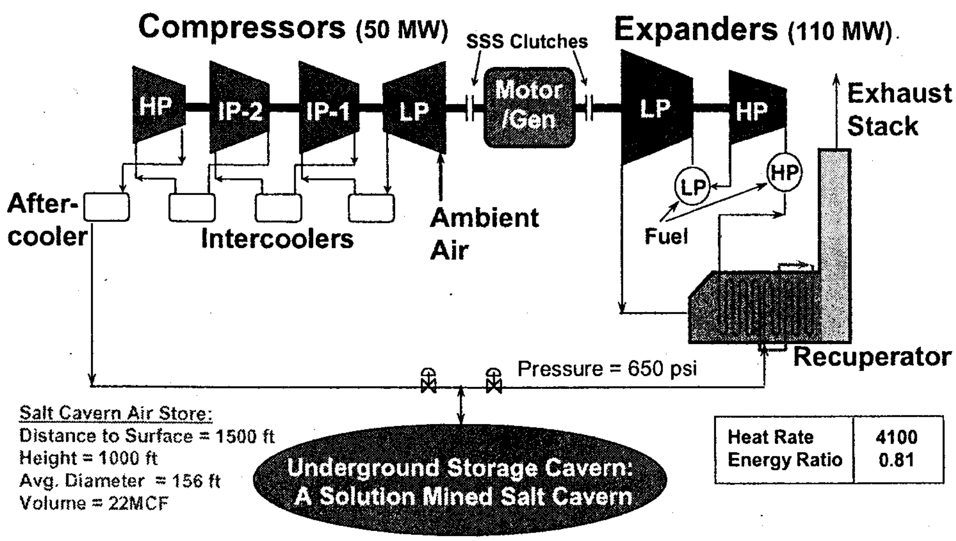
Dear Senator Black:

Via this letter I would like to introduce you to PB Energy Storage Services and take the opportunity to discuss a technology for Montana to expand its leadership position in the production of environmentally sound energy production. PB Energy Storage Services (PBESS) is the nation's leading engineer and constructor of underground storage. The firm was founded with the objective of providing a full range of quality services in the highly specialized field of subsurface systems technology, with particular emphasis on underground hydrocarbon storage and related facilities. Our firm is comprised of professional staff with the technical expertise and innovative spirit necessary to offer effective solutions in today's dynamic regulatory and business environments. PBESS is wholly owned by Parsons Brinckerhoff, a century-old firm ranked among the *Engineering News-Record's* top U.S. engineering firms.

The technology is **Compressed Air Energy Storage (CAES).** This technology, when paired with Montana's subsurface storage potential capacity, will continue your leadership position in the production of environmentally sound energy. CAES is used for electrical power generation during peak-use periods by storing compressed air in subsurface cavern structures such as aquifers, abandoned mines or solution-mined caverns in salt deposits. CAES refers to the compression of air during periods of low energy demand, typically at night, for use in meeting periods of higher demand during the day. Typically, compression is done with an electrically powered turbo-compressor; and expansion is done with a natural-gas powered 'expander' (heater) which drives a combustion turbine. PBESS was involved in the design and construction of the first installations of CAES systems in Huntorf, Germany (290 MW) and McIntosh, Alabama (110 MW) almost twenty years ago. The successful operation of the McIntosh and Huntorf plants has demonstrated the technical viability of CAES technology in supplying ancillary services, load following, and intermediate power generation.

The 110-MW McIntosh, AL AEC CAES plant was declared commercial on May 31, 1991. The system uses an underground solution mined cavern. The cavern is 220 feet in diameter and 1000 feet tall, for a total volume of 10 million cubic feet. At full charge, the cavern is pressurized to 1100 psi, and it is discharged down to 650 psi. During discharge, 340 pounds of air flow out of the cavern each second. The cavern can discharge at this rate for 26 hours. The compressed air feeds a 110-MW gas-fired combustion turbine. Compared to conventional combustion turbines, the CAES-fed system ***uses only 30% to 40% of the natural gas for a equivalent non-CAES plant***, operates efficiently down to low loads (about 25% of full load) and has a 95% reliability rate since inception.

Schematic for AEC CAES Plant
(110 MW – 26 Hour)



PB Power, another division of PB Americas, worked closely with PBESS in the design and construction of the McIntosh, AL AEC CAES plant. The PB Power engineers designed the critical integration of the underground storage with the selection of the above ground Turbomachinery and plant equipment for the plant and more recently have been involved in the design of several CAES projects in the development stages. PB Energy has also been directly involved with the development of advanced Turbomachinery CAES concepts. These concepts hold the promise for the future to provide more efficient and less costly configurations that can be integrated with wind and other renewable energies. PB has the expertise and experience to deliver the next generation of CAES projects.

Since atmospheric emissions are a major issue for the power industry, the environmental benefits of CAES technology are some of its most valuable attributes. The low thermal heat rate of a CAES plant enables it to produce power with approximately:

- 50% fewer tons of emissions than a comparably sized simple cycle gas plant
- 30% fewer tons of emissions than a comparably sized combined cycle gas plant

The ability to store off-peak power also enables CAES plants to displace emissions according to time and location. When power is produced during the day, the nitrogen oxide emitted during combustion reacts with volatile organic compounds in the presence of solar radiation to create ozone. A CAES plant is able to store power produced at night when emissions have less impact for use during the day.

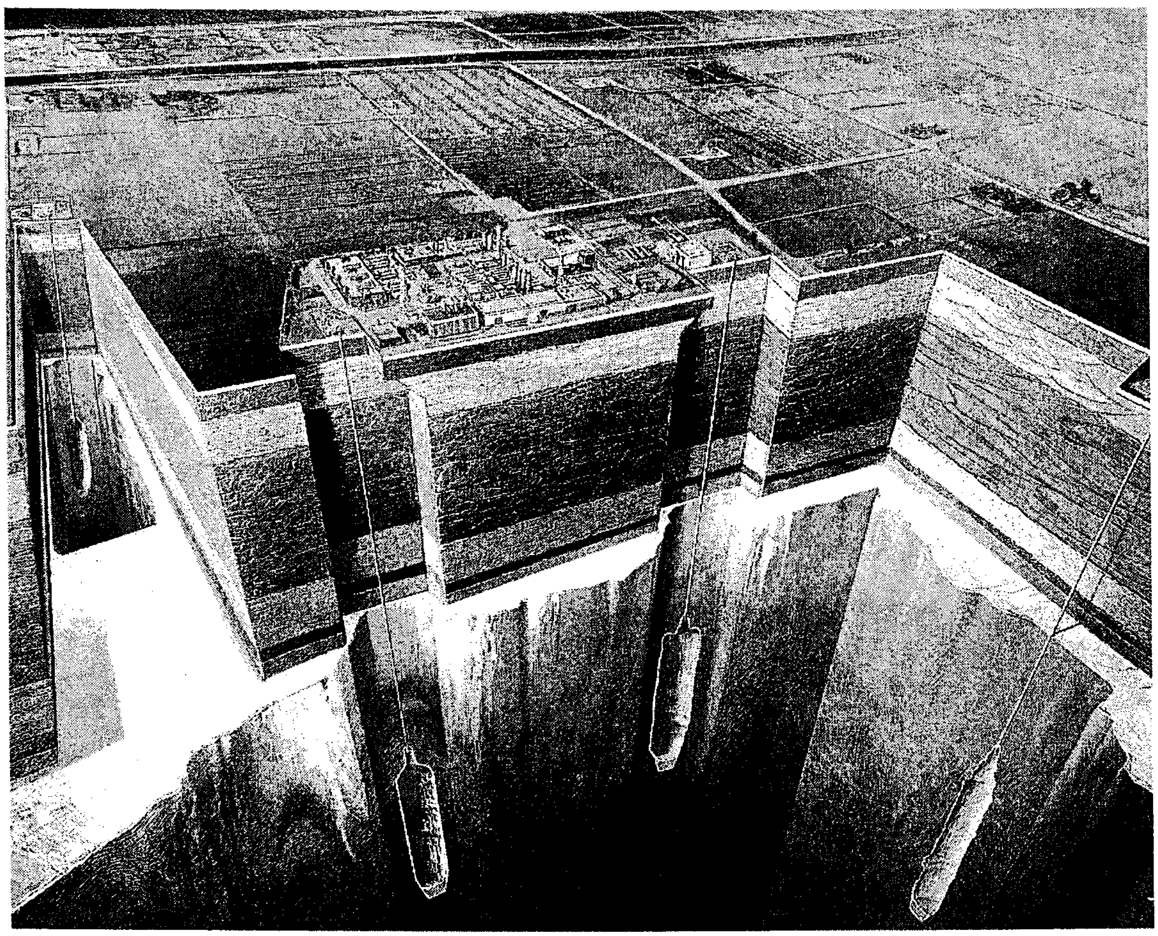
CAES can also displace emissions by geography by storing energy produced at another location. During off-peak periods, CAES plants in non-attainment zones can secure power that is generated outside their environmental area, reducing overall emissions in their zone. This flexibility is the reason why CAES is also a natural compliment to any wind production facility located in Montana. Working in conjunction with wind, CAES creates consistent power production to level out the uncertainty of the wind. Montana is poised to become the nation's leader in wind production, with more potential than any other state in the country and CAES is a time tested proven technology that is going to be an important part of our country's energy strategy going forward. PBESS wants to be part of that process and CAES will be an integral tool in making Montana a leader in the production of environmentally sound energy.

The largest factor in determining the viability of a CAES facility is the geologic conditions of the region. Montana is fortunate to have varied geologic formations to effectively utilize the three subsurface storage technologies that can be used for a CAES system. PBESS has gained industry recognition for the engineering, design and construction of all three underground storage systems. Each of these underground systems has been utilized for decades for the secure and environmentally safe storage of liquid and gaseous hydrocarbons and compressed air. Listed below are the three subsurface storage modes:

1. Aquifer & Depleted Reservoir Porous Rock Formations
2. Solution Mined Salt Caverns
3. Hard Rock Mined Storage Caverns

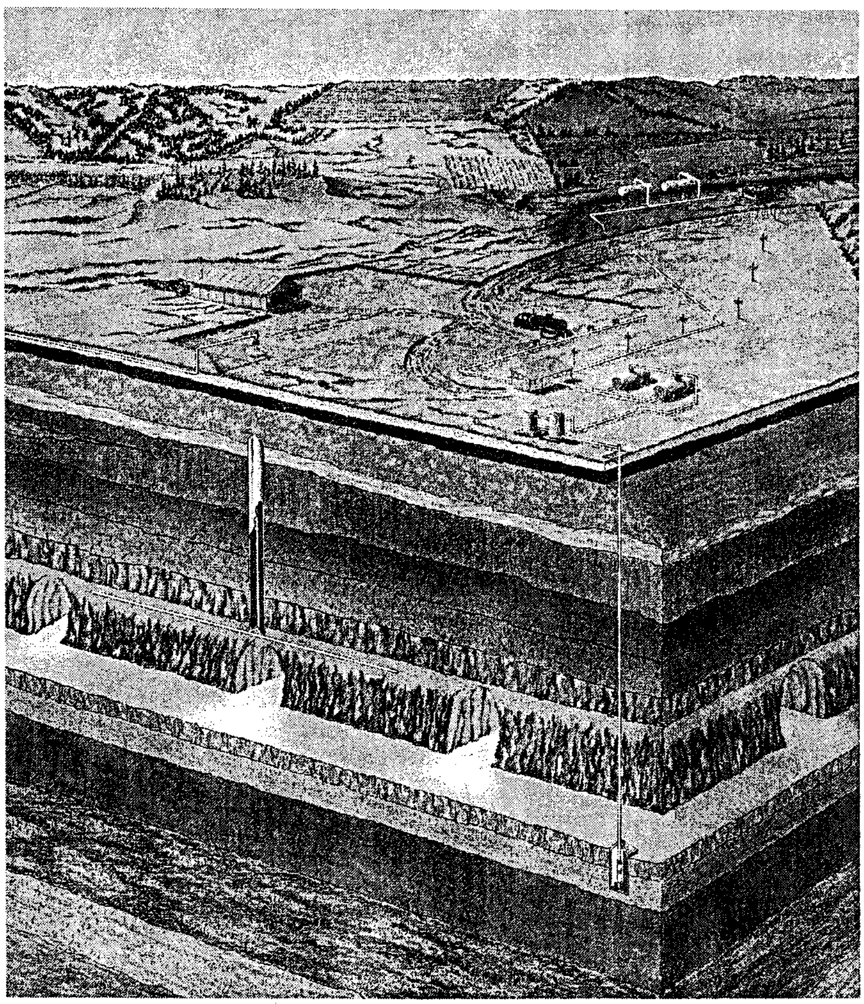
Aquifer & Depleted Reservoir Porous Rock Formations are found at depths of 1,500 feet or more. The free pore space of a suitable rock formation can often be used for storage of natural gas or compressed air. The rock formation layer must be adequately porous or fissured with good permeability and have an impermeable overburden which will not let the stored gas escape either vertically or laterally. Generally speaking, sandstones, dolomites, porous limestones or fractured rocks are suitable for such storage which is typical throughout Montana. The storage space in an aquifer is created by injected gas under pressure to displace free water. Depleted oil or gas reservoirs also represent a particular type of porous storage which can be also be found throughout Montana. PBESS engineers have analyzed numerous depleted oil and gas zones for natural gas and compressed air storage potential and have designed exploratory programs to locate and qualify aquifers.

Solution Mined Salt Caverns are created by drilling into salt formations, typically at depths of 1,000 to 6,000 ft below surface level, and injecting water and removing brine to form cavern space. The final cavern created can vary in depth from 1,000 to 2,000 ft tall with a diameter of up to 300 ft, resulting in very large storage volumes. The eastern third of Montana has extensive salt deposits to accommodate this type of storage. PBESS has provided solution mining in salt formations since 1950, having constructed over 150 solution-mined caverns for product storage, evaluated over 350 salt domes and developed more storage capacity than any other company in the world. We also constructed or converted 65 solution-mined storage caverns and one hard rock mine for the U.S. Strategic Petroleum Reserve with a combined storage capacity of 727 million barrels (4.1 billion cubic feet).



Solution Mined Salt Cavern Diagram

Hard Rock Mined Storage Caverns are created in rock formations on the crust of the earth using conventional mining techniques. Once created, they are a natural storage environment utilizing the principle of hydrostatic containment to store liquids and gases. Hard rock caverns provide highly protective and economical storage for hydrocarbons such as natural gas, propane, butane, crude oil and for compressed air. Whether developed in abandoned or depleted mines or newly constructed in rock formations - igneous, metamorphic or sedimentary - conventionally mined underground storage facilities have been designed, engineered, constructed and safely managed by PB Energy Storage Services for more than 50 years. With experience of 75 mined storage caverns with a combined total capacity of nearly 21 millions barrels, PB Energy Storage Services has perfected many construction techniques that are now a world standard.



Hard Rock Mined Storage Cavern Diagram

With is vast natural resources and forward thinking citizens, Montana is poised to become the national leader in environmentally sound energy production. Critical to the development of CAES and its integration into the state's energy production portfolio is the clear definition of what constitutes underground storage; and more specifically the ownership of the pore space in aquifers and depleted reservoir porous rock formations. We believe strongly that CAES will be an integral part of environmentally sound energy production in the future and PB will provide our expertise to assist the State of Montana to ensure its success.

Best regards,

Francis H Best

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